

Linear Technology in 42V Automotive Power

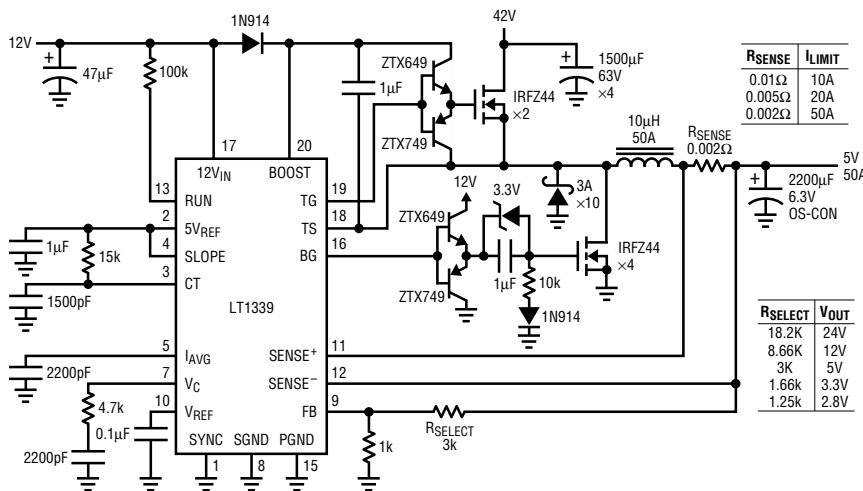
DC/DC conversion is a specialty of Linear Technology Corporation. We offer an extensive line of innovative circuits for automotive systems including switching regulators that operate to 60V or higher for the new 42V standard. These integrated circuits are available tested and guaranteed for the automotive temperature range.

High Current 42V Step-Down (to 3V, 5V, 14V, etc.)

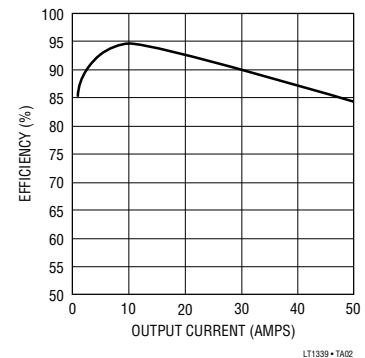
LT1339: High Power Synchronous DC/DC Controller – Up to 50A Output

- Operation to 60V
- Current Mode Operation
- Synchronous Dual N-Channel Drive
- Programmable Average Load Current Limiting
- Programmable Fixed Frequency Synchronizable to 150kHz
- Adaptive Nonoverlapping Gate Drive Prevents Shoot-Through

42V_{IN}, 5V_{OUT} at 50A High Power Buck Converter



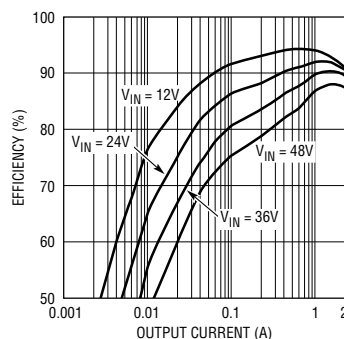
42V to 5V Efficiency Curve (R_{SENSE} = 0.002Ω)



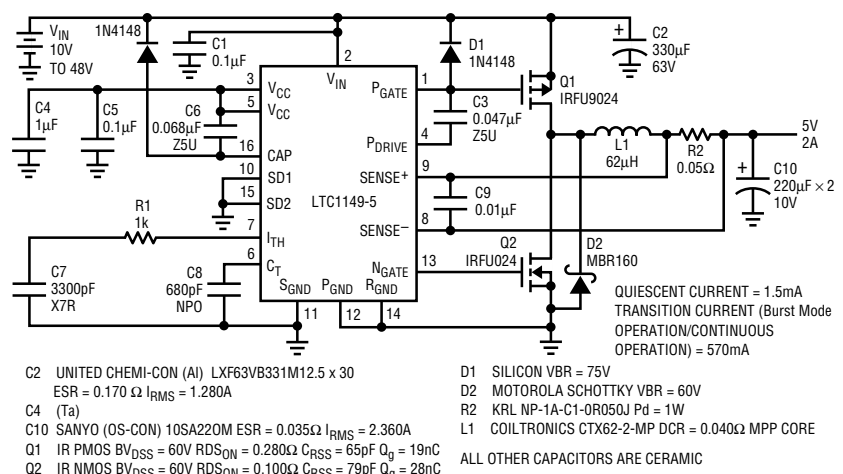
LTC1149: High Efficiency Synchronous DC/DC Controller – 60V Operation

- Operation to 60V, to 5A Output
- Constant Off-Time Current Mode Operation, to 250kHz
- High Efficiency over Wide Current Range
- Automatic Burst Mode™ Operation
- Logic-Controlled Micropower Shutdown
- Synchronous FET Switching for High Efficiency
- Adaptive Nonoverlap Gate Drives
- 16-Pin Narrow SO Package

10V-48V to 5V/2A High Voltage Buck Converter Measured Efficiency



10V-48V to 5V/2A High Voltage Buck Converter



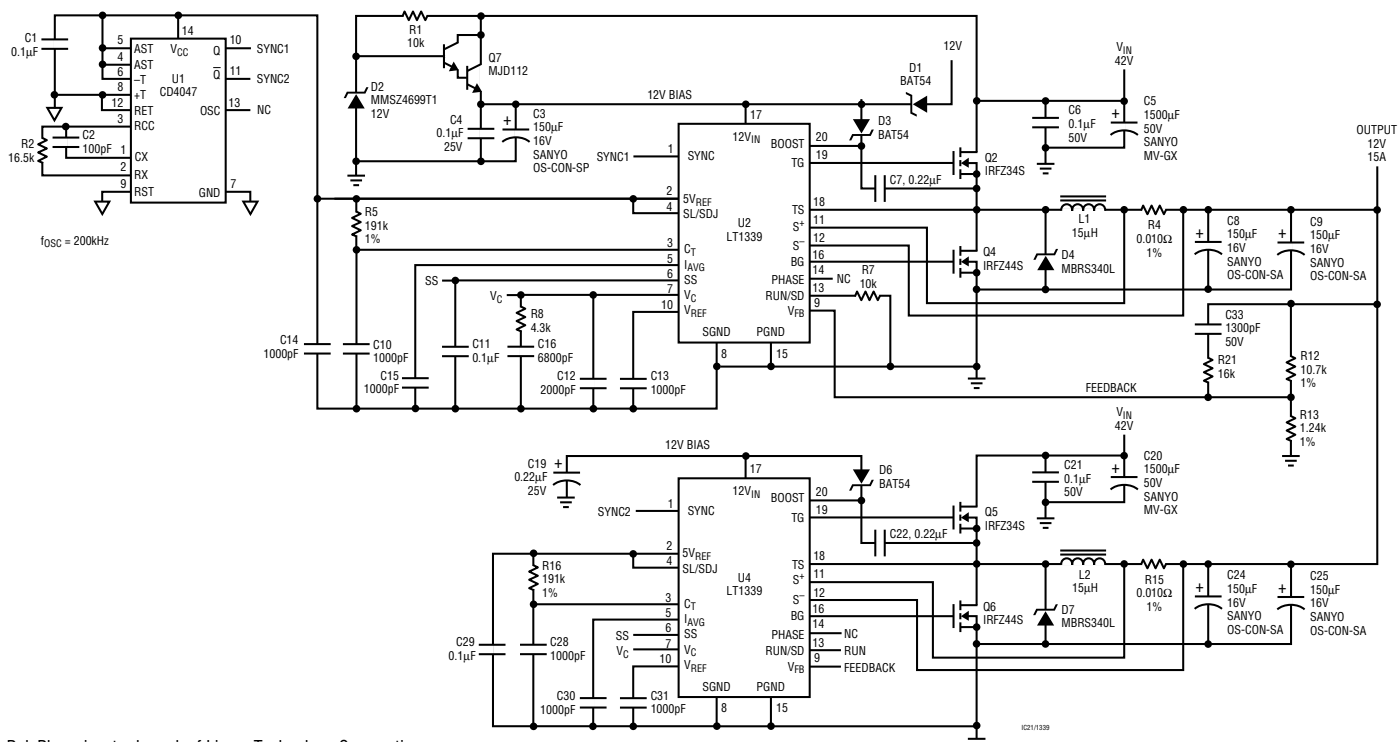
Burst Mode is a trademark of Linear Technology Corporation.

■ PolyPhase™ Regulators for Improved Performance

For high current step-down applications, two out-of-phase IC controllers provide significant improvements* and reduced component cost that offset the cost of the second controller IC. Major benefits include:

- Two Output Inductors 1/8 the Size of a Single Inductor (Total 1/4 the Magnetics)
- Significantly Reduced Output Ripple
- Significantly Reduced Input Capacitor Ripple Current Allows the use of Fewer Input Capacitors
- Greatly Improved Transient Response—Two Smaller Inductors: Slew Currents Are Additive
- Minimizes the Size of MOSFETs, May Save the Need to Parallel MOSFETs

Design Approach for Very Low Ripple/Noise and Improved Transient Response



PolyPhase is a trademark of Linear Technology Corporation.

*See *Linear Technology* magazine, November 1998, p.27

■ Selection Guide for 42V Automotive DC/DC Conversion

Regulator Circuit	V _{IN} Range	I _{OUT} Range	Synch Drive*	Burst Mode	I _Q Supply	Shutdown Current	Package	Features
60V Input Step-Down Switching Regulators								
LT1676	7.4V to 60V	10mA to 500mA		X**	3.2mA†	30µA	S8	No Pulse Skipping at Light Load, 100kHz
LT1776	7.4V to 60V	10mA to 500mA		X**	3.2mA†	30µA	S8	No Pulse Skipping at Light Load, 200kHz
LT1076HV	8V to 64V	to 2A			8.5mA	140µA	K,T,R	Onboard Switches
LT1074HV	8V to 64V	to 5A			8.5mA	140µA	K,T,T7	Low Quiescent Current
LTC1149	4V to 60V	to 5A	Yes	X	2mA	135µA	S16	High Efficiency over Wide Range
LT1339	10V to 60V	1A to 50A	Yes		14mA††	65µA	N20, SW20	High Current N-Channel Drive
42V Output Step-Up (or SEPIC) Switching Regulators								
LT1680	10V to 60V	1A to 50A			12mA	65µA	N16, SW16	To 10,000pF Gate Capacitance
LT1339	10V to 60V	1A to 50A	Yes		16mA††	65µA	N20, SW20	Adaptive Gate Drive
LTC1624	3.5V to 36V	10A		X	550µA	16µA	S8	Optimum Load Step Response

* Synchronous 2-switch transistor drive for maximum efficiency

** External comparator required

† Plus minimum V_{CC} load of a few mA

†† Plus FET charge currents

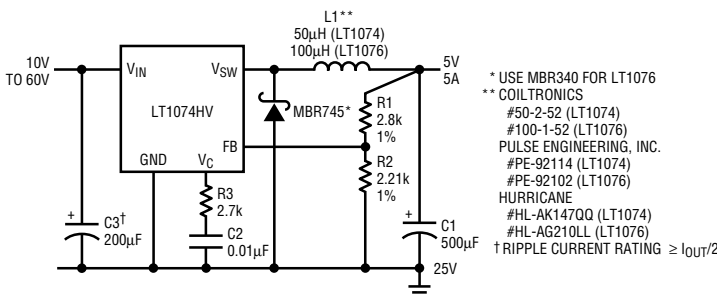
Package Codes: K = TO-3, N = Plastic Power DIP, R = 7-Lead DD, S = Narrow Small Outline, SW = Wide SO (0.300"), T = TO-220,

■ 42V Step-Down (Integrated Switch)

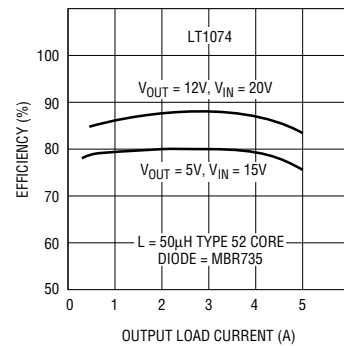
LT1074 Series: High Voltage, High Efficiency Switching Voltage Regulators

- Input Voltage Range to 60V or 75V
- 1A, 2A and 5A Onboard Switches (see Table, p.6)
- Current Mode Operation, May Be Synchronized to External Clock
- Few External Components
- Low Quiescent Current: < 10mA
- Micropower Shutdown Mode
- Pulse-by-Pulse Programmable Current Limiting
- Low Thermal Resistance Packages

Basic Positive Buck Converter

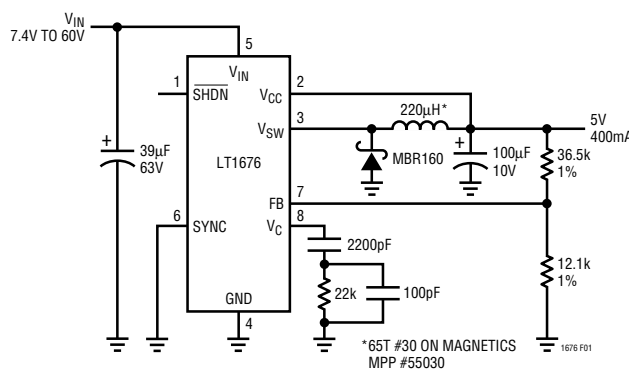


Buck Converter Efficiency

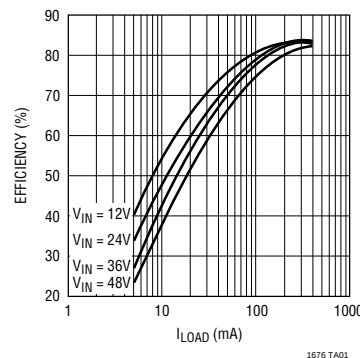


LT1676/LT1776: High Efficiency Step-Down Switching Regulators

- Wide Input Range: 7.4V to 60V*
- True Current Mode Control
- 700mA Peak Switch Current
- Adaptive Switch Drive Prevents Pulse Skipping at Light Loads
- Fixed Frequency LT1676: 100kHz, LT1776: 200kHz
- LT1676 Is Synchronizable to 250kHz (LT1776 to 400kHz)
- Micropower Shutdown Mode
- 8-Pin SO and Power DIP Packages



Efficiency vs V_{IN} and I_{LOAD}



* The LT1776 is limited to 40V continuous DC input due to thermal constraints, but can withstand transients up to 60V.

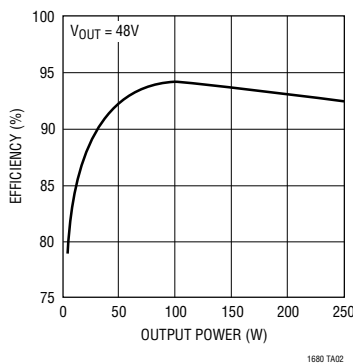
■ High Current 14V to 42V Step-Up DC/DC Conversion

For charging 36V batteries or powering 42V equipment from a 12V source

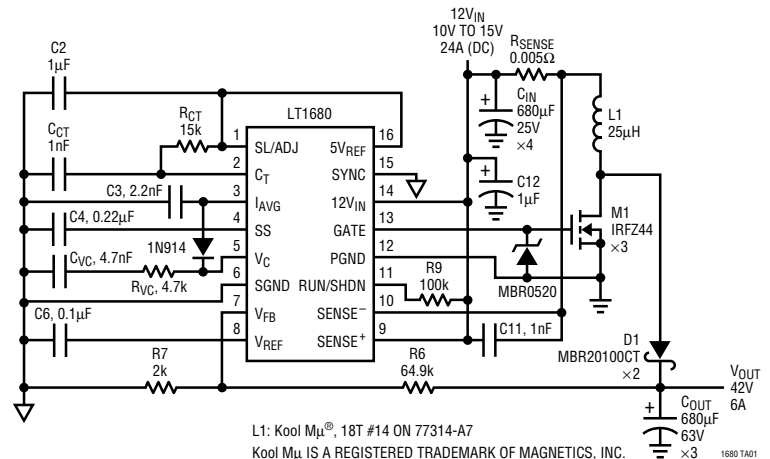
LT1680: High Power DC/DC Step-Up Controller

- Operation to 60V
- All N-Channel Drive Handles up to 10,000pF Gate Capacitance
- High Power Output to 250W or More
- Fixed Frequency Current Mode Operation
- Synchronizable to 200kHz
- Programmable Average Current Limiting
- Undervoltage Lockout with Hysteresis
- User-Adjustable Slope Compensation
- 16-Pin SO and DIP Packages

Efficiency vs Output Power



12V to 42V, 250W Boost



The LT1339 will also provide 42V output, high current synchronous boost conversion (see data sheet).

Automotive Power Circuits

Battery Charger Circuits (For In-Vehicle Cell Phones, PCs, etc.)

Power Circuit	V _{IN} Range*	I _{OUT} Max	Step-Up/Down	Batteries Charged	I _Q Supply	Shutdown Current	Packages	Description or Features
LT1505	3V to 27V	>5A		NiCd, NiMH, Li-Ion, SLA	12mA	5μA	G24	Programmable or Preset Outputs; Constant I & V 200kHz or 500kHz Switching; Precision Reference With Input Current Limiting; Undervoltage Lockout Step-Up/Step-Down; 500kHz; Constant I/Constant V Any Number of Cells to 20V [†] ; Programmable Current Sense Amp Used with PWM Controller IC
LT1510	8V to 30V	1.5A		NiCd, NiMH, Li-Ion	2.9mA	3μA	S8, N16, GN16	
LT1511	8V to 30V	3A		NiCd, NiMH, Li-Ion	4.5mA	3μA	SW24	
LT1512	3V to 30V**	1A	X	NiCd, NiMH, Li-Ion, SLA	4mA	12μA	N8, S8	
LT1513	3V to 30V**	2A	X	NiCd, NiMH, Li-Ion, SLA	4mA	12μA	T, R	
LT1620/1	to 32V	>10A		NiCd, NiMH, Li-Ion, SLA	2.8mA		MS8, S8, GN	

* Depending on battery types and quantity

** 40V max for on-chip switch

[†] LT1512 to 30V

Power Driver Circuits

Power Circuit	V _{IN} Range	I _{OUT} Max	Number Drivers	Transient Protection	Reverse Polarity	I _Q Supply	Shutdown Current	Packages	Description or Features
Fully Enhanced MOSFET Drivers									
LTC1153	4.5V to 22V	>20A	Single	40V*	15V	85μA	8μA	N8, S8	Autoreset Electronic Circuit Breaker
LTC1154	4.5V to 22V	2.7A	Single	40V*	15V	85μA	8μA	N8, S8	High Side MOSFET Driver
LTC1155	4.5V to 22V	5A	Dual	40V*	15V*	85μA	8μA	N8, S8	Micropower MOSFET Driver; Overcurrent Sense
High Voltage Switch Drivers									
LT1161	8V TO 48V	to 5A	Quad	60V	15V	4.5mA		N20, S20	External MOSFETs; -15V to 60V Transients
LT1188	5V to 30V	1.5A	Single	60V		5mA		K, T	On-Chip Switch; Status Output
LTC1255	9V to 24V	1A	Dual	40V*	15V	0.5mA	12μA	N8, S8	External MOSFETs; Overvoltage Protection

* With external diode

Package Codes: G = SSOP (0.209" Wide), GN = Narrow SSOP (0.150"), GW = Wide SSOP (0.300"), M = 3-Lead DD, MS8 = 8-Lead MSOP, N = Plastic DIP, Q = 5-Lead DD, R = 7-Lead DD, S = Narrow Small Outline (SO), ST = SOT-223, T = Plastic TO-220

Automotive Power Circuits

Switching Regulator DC/DC Converters

Power Circuit	V _{IN} Range	I _{OUT} Max	Step-Up & SEPIC	Step-Down	Switch Volts	Burst Mode	I _Q Supply	Shutdown Current	Packages	Description or Features
High Efficiency Current Mode Switching Regulators (On-Chip Power Transistor)										
LT1676	7.4V to 60V	500mA		X	60V	X*	3.2mA**	30μA	N8,S8	No Pulse Skipping at Light Load; Fixed 100kHz
LT1776	7.4V to 60V	500mA		X	60V	X*	3.2mA**	30μA	N8,S8	Fixed 200kHz, Synchronize to 400kHz
LT1082	3V to 75V	1A*†	X		100V		4.5mA	120μA	Q,T, N8	Highest Input Voltage; All Standard Switch Configurations
LT1072	8V to 40V	1.25A*†	X		60V		6mA	50μA	K,T,N8,S8	Self-Protected Against Overloads; Easy to Use
LT1072HV	8V to 64V	1.25A*†	X		84V		6mA	50μA	K,T,N8,S8	Optional Flyback-Regulated Mode for Isolation
LT1172	3V to 60V	1.25A*†	X		60V		6mA	50μA	K,T,N8,S16	Adaptive Antisat Switch Drive
LT1176	5V to 38V	1A		X	50V		8mA	140μA	N8,S20	100kHz; Few External; Improved Dynamic Behavior
LT1071	3V to 60V	2.5A*†	X		60V		6mA	50μA	K,T	Bust Proof and Easy to Use
LT1076	8V to 45V	2A		X	45V		8.5mA	140μA	K,T,R	Adjustable or Fixed Current Limit; Self-Protecting
LT1076HV	8V to 64V	2A		X	84V		8.5mA	140μA	K,T,R	Switch Voltage to 84V; to 64V Input Voltage
LT1171	3V to 60V	2.5A*†	X		60V		6mA	50μA	K,T,N8,S16	Self-Protected Against Overloads
LT1070	3V to 60V	5A*†	X		60V		6mA	50μA	K,T	Load Power to 100W
LT1170	3V to 60V	5A*†	X		60V		6mA	50μA	K,T,N8,S16	100kHz, High Efficiency
LT1074	8V to 45V	5A		X	64V		8.5mA	140μA	K,T	Pulse-by-Pulse Current Limiting
LT1074HV	8V to 64V	5A		X	84V		8.5mA	140μA	K,T	Switch Voltage to 84V; 100kHz
LT1372	2.7V to 30V	1.5A*†	X		35V		4mA	12μA	N8,S8	500kHz, High Efficiency
LT1377	2.7V to 30V	1.5A*†	X		35V		4mA	12μA	N8,S8	1MHz, Tiny Inductors
LTC1574	4.5V to 18.5V	1A		X	18.5V	X	450μA	2μA	S16	Internal Schottky Diode
LT1375	6V to 25V	1.2A		X	35V		2.5mA	20μA	N8,S8	May Be Externally Synchronized to 1MHz
LT1376	6V to 25V	1.2A		X	35V		2.5mA	20μA	N8,S8,S16	500kHz; Cycle-by-Cycle and Thermal Protection
LT1373	2.7V to 30V	1.5A*†	X		35V		1mA	12μA	N8,S8	35V Switch; 250kHz; Easily Synchronized
LT1371	2.7V to 30V	3A*†	X		35V†		4mA	12μA	R,SW20	500kHz, High Efficiency; Reduced Overshoot
LT1374	6V to 25V	4.5A		X	40V		2.5mA	20μA	S8	Constant 500kHz, Synchronize to 1MHz, 1.8μH
LT1370	2.7V to 30V	6A*†	X		35V†		4.5mA	12μA	R,T7	500kHz, Tiny Inductors; Easy Synchronization
Ultralow Noise Switching Regulators (On-Chip Switch)										
LT1533	2.7V to 23V	2x1A*†	X	X	30V		12mA	12μA	S16	Ultralow Noise 1A Push-Pull Regulator
LT1534	2.7V to 23V	2A*†	X		30V		12mA	12μA	S16	Ultralow Noise 2A Boost Regulator

*† Maximum switch current

* With external comparator

** Plus minimum V_{CC} load of a few mA

† 45V with HV version

Power Circuit	V _{IN} Range	I _{OUT} Max	Step-Up & SEPIC	Step-Down	Sync* Drive	Burst Mode	I _Q Supply	Shutdown Current	Packages	Description or Features
Switching Regulator Controllers (External Power Transistors)										
LTC1148HV	4V to 20V	10A		X	X	X	1.6mA	10μA	N14,S14	Very High Efficiency
LTC1149	4V to 60V	5A		X	X	X	2mA	300μA	N16,S16	High Efficiency over Wide Range; to 250kHz
LTC1159	4V to 40V	5A		X	X	X	300μA	20μA	N16,S16,G20	High Efficiency over Wide Range
LTC1267	4V to 40V	5A		X	X	X	550μA	25μA	G28	Dual Regulators
LTC1435A	3.5V to 36V	5A		X	X	X	260μA	25μA	G16,S16	Ultrahigh Efficiency, to 99% Duty Cycle
LTC1436A	3.5V to 36V	5A		X	X	X	260μA	25μA	GN24	2.9V/5A with 5V Auxiliary Output
LTC1437A	3.5V to 36V	5A		X	X	X	260μA	25μA	G28	2.5V/5A Adjustable Output with 5V Auxiliary Output
LTC1438/9	3.5V to 36V	5A		X	X	X	320μA	30μA	G28,GW36	Dual 5V/3V Step-Down Converter, 400kHz
LTC1538/9	3.5V to 36V	5A		X	X	X	320μA	70μA	G28,GW36	Dual Regulators, Adaptive Drive
LTC1624	3.5V to 36V	10A	X	X		X	550μA	16μA	S8	Very Low Dropout, Also Good for Flyback and Inverting
LTC1625	3.7V to 36V	10A		X	X	X	500μA	30μA	GN,S16	No Sense Resistor Required
LT1339	60V MAX	>50A	X	X	X		14mA††	65μA	N20,SW20	High Power Synchronous Current Mode
LT1680	60V MAX	20A	X				12mA	65μA	N16,SW16	High Power Step-Up Converter

* Synchronous 2-switch transistor drive for maximum efficiency

†† Plus FET charge current

Low Dropout Voltage Linear Regulators

Power Circuit	V _{IN} Range	I _{OUT} Max	Dropout Max	Transient Protection	Reverse Polarity	I _Q Supply	Shutdown Current	Packages	Description or Features
LT1020	5V to 36V	125mA	0.6V	36V		40μA		N8,S8	With Comparator and Reference Class B Outputs
LT1120	to 36V	125mA	0.65V	36V		40μA		N8,S8	With Comparator and Reference; Logic Shutdown
LT1121	to 30V	150mA	0.4V	30V*	30V	30μA	16μA	Z,N8,S8,ST	Adjustable or Fixed; Micropower; Self-Protection
LT1521	to 20V	300mA	0.6V	20V*	20V	12μA	5μA	MS8,S8,ST	No Protection Diodes Required
LT1129	to 30V	700mA	0.4V	30V*	30V	50μA	16μA	R,S8,T,ST	Adjustable or Fixed; Micropower; Self-Protection
LT1086	to 25V	1.5A	1.5V	30V*		5mA**		K,T,M	Adjustable or Fixed
LT1085	to 25V	3A	1.5V	30V*		5mA**		T,M	Handle Surge Currents to 100A
LT1084	to 25V	5A	1.5V	30V*		5mA**		K,P,T	Pin Compatible with 3-Terminal Regulators
LT1083	to 25V	7.5A	1.5V	30V*		5mA**		K,P	Fixed 3.3V, 3.6V, 5V, 12V; Adjustable Versions

* For higher ratings, consult factory

** Flows into the load for higher efficiency